WE CLAIM:

1. A group III nitride based diode, comprising:

an n+ doped GaN layer;

an n- doped GaN layer on said n+ GaN layer;

a Schottky metal layer on said n- doped GaN layer having a work function, said n- GaN layer forming a junction with said Schottky metal, said junction having a barrier potential energy level that is dependent upon the work function of said Schottky metal.

2. The diode of claim 1, wherein said barrier potential varies directly with said Schottky metal work function.

3. The diode of claim 1, wherein said n- doped GaN layer has an electron affinity, said barrier potential being generally equal to said Schottky metal work function minus said electron affinity.

4. The diode of claim 1, further comprising a substrate adjacent to said n+ GaN layer, opposite said n- doped GaN layer.

5. The diode of claim 4, wherein said substrate is sapphire (Al_2O_3), silicon carbide (SiC) or silicon (Si).

6. The diode of claim 1, wherein said Schottky metal is one of the metals from the group comprising Ti, Cr, Nb, Sn, W, Ta and Ge.

7. The diode of claim 1, wherein said n+ doped GaN layer is doped with impurities to a concentration of at least 10^{18} per centimeter cubed (cm^3).

8. The diode of claim 1, wherein the n- doped GaN layer is doped with impurities to a concentration in the range of 5×10^{14} to 5×10^{17} per cm^3.

9. The diode of claim 1, further comprising a trench structure in said n- doped GaN layer, said diode experiencing a reverse leakage current under reverse bias, said trench structure reducing said reverse leakage current.

10. The diode of claim 9, wherein said trench structure comprises a plurality of trenches with mesa regions between adjacent trenches, said trenches having sidewalls and a bottom surface coated by an insulating material, said Schottky metal layer covering said trenches and mesa regions, said insulating material sandwiched between said Schottky metal layer and said sidewalls and bottom surfaces.

11. The diode of claim 10, wherein said plurality of trenches are parallel and equally spaced.

12. The diode of claim 10, wherein said insulating material is SiN.

13. The diode of claim 10, wherein said insulating material is replaced by a metal with a high work function.

14. The diode of claim 1, further comprising an ohmic contact on said n+ GaN layer, a signal applied to said device across said ohmic contact and said Schottky metal layer.

15. A diode, comprising:

a layer of highly doped semiconductor material having an unpinned surface potential;

a layer of lower doped semiconductor material adjacent to the highly doped semiconductor material; and

a Schottky metal layer on said lower doped semiconductor material, said lower doped semiconductor material forming a junction with said Schottky metal having a barrier potential energy level that is dependent upon the type of Schottky metal.

16. The diode of claim 15, wherein said doped layers are doped n type.

17. The diode of claim 15, wherein said semiconductor material is a Group III nitride.

18. The diode of claim 15, wherein said highly doped semiconductor is n+ doped GaN layer and said lower doped semiconductor is n- doped GaN layer.

19. The diode of claim 15, wherein said Schottky metal contact has a work function, said barrier potential having an energy level that varies directly with the work function of said Schottky metal.

20. The diode of claim 15, further comprising a substrate adjacent to said n+ doped GaN layer, opposite said n- doped GaN layer.

21. The diode of claim 20, wherein said substrate is sapphire (Al_2O_3), silicon carbide (SiC) or silicon (Si).

22. The diode of claim 15, wherein said Schottky metal is one of the metals in the group comprising Ti, Cr, Nb, Sn, W, Ge and Ta.

23. The diode of claim 18, wherein said n+ doped GaN layer is doped with impurities to a concentration of at least 10^{18} per centimeter cubed (cm^3).

24. The diode of claim 18, wherein the n- doped GaN layer is doped with impurities to a concentration in the range of 5×10^{14} to 5×10^{17} per cm^3.

25. The diode of claim 15, further comprising a trench structure on the surface of said lower doped semiconductor material, said diode experiencing a reverse leakage current under reverse bias, said trench structure reducing the amount of reverse leakage current.

26. The diode of claim 25, wherein said trench structure comprises a plurality of trenches with mesa regions between adjacent trenches, each of said trenches having sidewalls and a bottom surface coated by an insulating material, said Schottky metal layer covering said trenches and mesa regions, said insulating material sandwiched between said Schottky metal layer and said sidewalls and bottom surfaces.

27. The diode of claim 26, wherein said insulating material is replaced by a metal with a high work function.

28. The diode of claim 15, further comprising an ohmic contact on said higher doped semiconductor material.

29. A tunneling diode comprising:

an n+ doped layer;

an n- doped layer adjacent to said n+ doped layer;

a barrier layer adjacent to said n- doped layer, opposite said n+ layer; and

a metal layer on said barrier layer, opposite said n-doped layer, said n- doped layer forming a junction with said barrier layer that has a barrier potential which causes said diode's on state voltage to be low as a result of electron tunneling through the barrier potential under forward bias.

30. The diode of claim 29, wherein said barrier layer has piezoelectric dipoles that lower the diode's on state voltage by enhancing electron tunneling.

31. The diode of claim 29, wherein the number of piezoelectric dipoles increases as the thickness of said barrier layer increases, while still allowing tunneling currents.

32. The diode of claim 29, further comprising a substrate adjacent to said n+ doped layer opposite said n- doped layer, said substrate comprising sapphire, silicon carbide or silicon.

33. The diode of claim 29, wherein said n+ doped layer, n- doped layer and barrier layer comprise polar materials.

34. The diode of claim 29, wherein said n+ doped layer, n- doped layer and barrier layer are from the Group III nitride material system.

35. The diode of claim 29, wherein said n+ doped layer is GaN, said n- doped layer is GaN, and said barrier layer is AlGaN.

36. The diode of claim 29, wherein said n+ doped layer, n-doped layer and barrier layer are formed from polar or non-polar materials, or combinations thereof.

37. The diode of claim 29, wherein said n+ doped layer, n-doped layer and barrier layer are formed from complex polar oxides such as strontium titanate, lithium niobate, lead zirconium titanate, or combinations thereof.

38. The diode of claim 29, wherein said n+ doped layer, n-doped layer and barrier layer from binary polar oxides such as zinc oxide.

39. The diode of claim 29, further comprising a trench structure in said barrier and n- doped layers, said diode experiencing a reverse leakage current under reverse bias, said trench structure reducing the amount of said reverse leakage current.

40. The diode of claim 29, wherein said trench structure comprises a plurality of trenches in said barrier and said n- layers having mesa regions between adjacent trenches, each of said trenches having sidewalls and a bottom surface coated by an insulating material, said Schottky metal layer covering said trenches and mesa regions, said insulating material sandwiched between said Schottky metal layer and said sidewalls and bottom surfaces.

41. The diode of claim 40, wherein said insulating material is replaced by a metal with a high work function.

42. The diode of claim 29, further comprising an ohmic contact on said n+ doped layer.

43. A Schottky diode, comprising:

a semiconductor material having an unpinned surface potential; and

a Schottky metal having a work function and forming a junction with said semiconductor material that has a barrier potential, the height of said barrier potential depending upon said work function.

44. The diode of claim 43, wherein said semiconductor material is Group III nitride based.

45. The diode of claim 43, wherein said semiconductor layer comprises adjacent n- doped GaN and n+ doped GaN layers.

46. The diode of claim 45, further comprising an ohmic contact on said n+ doped GaN layer, with said Schottky metal contacting said n- GaN layer.

47. The diode of claim 43, wherein the height of said barrier potential varies positively with the work function of said Schottky metal.

48. The diode of claim 45, further comprising a substrate made of sapphire (Al_2O_3), silicon carbide (SiC) or silicon (Si), adjacent to the said n+ GaN layer, opposite said n- GaN layer.

49. The diode of claim 43, wherein said Schottky metal is one of the metals in the group comprising Ti, Cr, Nb, Sn, W, Ta, Ge and other metals with similar work functions.

50. The diode of claim 43, further comprising a trench structure in said semiconductor material, said diode experiencing a reverse leakage current under reverse bias, said trench structure reducing said reverse leakage current.

51. The diode of claim 43, wherein said trench structure comprises a plurality of trenches with mesa regions between adjacent trenches, said trenches having sidewalls and a bottom surface coated by an insulating material, said Schottky metal layer covering said trenches and mesa regions, said insulating material sandwiched between said Schottky metal layer and said sidewalls and bottom surfaces.